# Report for 2003WY12B: Water Scarcity and Economic Growth in Wyoming

- Conference Proceedings:
  - Barbier, E.B. and A. Chaudhry. 2004. Water and Growth in an Agricultural Economy. Paper to be presented at the Thirteenth Annual Conference of European Association of Environmental and Resource Economists, Budapest University of Economic Sciences and Public Administration, Budapest, 25-28 June 2004.
- Other Publications:
  - Chaudhry, A. 2004. Water, Public Capital and Growth in Municipal and Industries. Mimeo. Department of Economics and Finance, University of Wyoming.
- Articles in Refereed Scientific Journals:
  - Barbier, E.B. 2004. Water and Economic Growth, Economic Record, 80: 1-16.

Report Follows

**Abstract:**

The persistence of drought conditions over much or all of the state of Wyoming in recent years has raised concern as to whether water availability relative to use may be limiting economic growth and development in certain regions or even state-wide. This research aims to address this issue by analyzing the relationship between relative water availability and economic growth across the counties and key water-using sectors in Wyoming, irrigated agriculture and other productive uses (municipal and industrial). Three broad results are anticipated: 1) An empirical analysis of the relationship between the rate of water utilization and economic growth across the individual counties of Wyoming and over time (i.e. annually). 2) An empirical analysis over time (i.e. annually) of a water-growth relationship for two key water-using sectors in Wyoming's economy: irrigated agriculture (i.e. the annual crop sector fodder and municipal and industrial users (for production). 3) Identification of those counties and sectors whose economic development is especially at risk from chronic water scarcity, as measured in terms of moderate and/or extreme hydrological stress conditions.

**Problem and Research Objectives:**

The persistence of drought conditions over much or all of the state of Wyoming in recent years has raised concern as to whether water availability relative to use may be limiting economic growth and development in certain regions or even state-wide. The primary objective of this study is to analyze the relationship between relative water availability and economic growth across the counties and key water-using sectors in Wyoming. Jacobs and Brosz 2000) indicate that 80-85% of water consumed in Wyoming is for irrigated agriculture (approximately 2.6 million acre-feet). Ignoring evaporation from reservoirs, all other water uses in Wyoming (domestic, municipal, livestock and industrial – including mineral and energy) account for 160,000 acre-feet of water consumption. Thus it is important to analyze water-growth relationships in Wyoming for two distinct uses: irrigated agriculture, and other productive water uses (municipal and industrial).

The modeling approach is based on adapting the approach by Barbier (2004), which depicts the influence of water utilization on the growth of the economy through a model that includes this congestible public good as a productive input for private producers. The result is that the aggregate rate of water utilization by all producers is related directly to the growth of the economy. In Barbier (2004), this relationship was empirically tested through a statistical analysis across countries, and allowing for the fact that some countries face moderate or extreme conditions of water stress. The aim of the proposed research is to modify the water-growth model and apply it to the state of Wyoming.

Two types of analysis are being conducted. The first involves examining empirically the relationship between the rate of water utilization and economic growth across the individual counties of Wyoming and over time (i.e. annually). The degree of water stress faced by certain counties in some years will be incorporated specifically into the analysis. The second analysis also involves examining the water-growth relationship over time but for the two sector principal uses: irrigated agriculture and all other productive uses of water. Analyzing the latter category of use is particularly important, as surface water consumption for domestic and municipal use is anticipated to increase from 60,000 to over 148,000 acre-feet in 2020, and industrial consumption is projected to rise from 85,000 to over 845,000 acre-feet in 2020 (Jacobs and Brosz 2000).

Both the county and sector-level analyses will not only reveal the extent to which overall economic growth in Wyoming is affected by water availability relative to use but also identify those counties and sectors whose economic development is especially at risk from water scarcity. Such information may be critical to future water use planning in Wyoming, and for the design and implementation of institutional and allocation mechanisms for water supply in the state.

**Methodology and Anticipated Results:**

The methodological approach for the empirical panel analysis of the relationship between the rate of water utilization and economic growth across the individual counties of Wyoming and over time will be a straightforward application of the model developed by Barbier (2004). In contrast, analyzing water-growth relationships for the two main categories of sectoral use, irrigated agriculture and municipal and industrial use, requires two distinct modeling approaches.

For example, irrigated water is a privately provided good, usually supplied by farmers to themselves through exercising their prior appropriation rights. A different modeling approach is required to determine how the aggregate rate of water utilization for irrigated farming affects growth in this sector of the economy. Preliminary efforts to develop such a model for water use in irrigated agriculture are summarized in Barbier and Chaudhry (2004). Future work will focus on applying this model to empirical data across Wyoming.

In the case of municipal and industrial use, combing the modeling approach developed in Barbier (2004) with a model of public capital and economic growth by Shioji (2001) seems appropriate. In this approach we suggest that water is provided to producers as a publicly provided but congestible good, and we focus on investment in water-related infrastructure (e.g. water delivery, cleaning and storage) as well as the total volume of water availability (Chaudhry 2004). The result is that the aggregate rate of water utilization by all producers is related directly to the growth of production in this sector of the economy.

In sum, we anticipate the following three results from the study:

- An empirical analysis of the relationship between the rate of water utilization and economic growth across the individual counties of Wyoming and over time (i.e. annually).
- An empirical analysis over time (i.e. annually) of a water-growth relationship for two key water-using sectors in Wyoming's economy: irrigated agriculture (i.e. the annual crop sector fodder and municipal and industrial users (for production).
- Identifying those counties and sectors whose economic development is especially at risk from chronic water scarcity, as measured in terms of moderate and/or extreme hydrological stress conditions.

**Summary of Progress in FY2003:**

A graduate assistant, Ms Anita Chaudhry, has been appointed to the project. Ms. Chaudhry is undertaking this project as part of her PhD studies, supervised by the principal investigator, Professor Edward Barbier.

Professor Barbier outlined the scope and aims of the project at the 2003 Stroock Forum at the University of Wyoming on 16 September 2003 in a presentation, “Water Scarcity, Wyoming and River Basins”.

One of the aims of the project in FY2003 has been to develop the various methodologies for analyzing water use and growth in the two main sectors, irrigated agriculture and municipal/industrial use. It was decided that the Barbier (2003) model could be readily adapted

to analyze water-growth relationships for producers in the water/industrial use sector but not for irrigated agriculture. We are therefore in the process of developing an appropriate model for the latter sector, taking into account that irrigated water is a privately provided good, usually supplied by farmers to themselves through exercising their prior appropriation rights.

A major focus in the first year has been to identify useful contacts in the State and Federal agencies concerned with water use in Wyoming, and to collect the appropriate hydrological, demographic and economic data necessary for the project. The following summarizes our progress to date in this area:

*People contacted*

- State Engineer's Office: Patrick Tyrrell
- Wyoming Water Development Commission: Barry B. Lawrence
- United States Geological Service: Bob Swanson, Timothy T. Bartos
- Water Resources Data System: Jan Curtis, Debra Cook

*Hydrological data*

- United States Geological Service (http://water.usgs.gov/watuse/ )

This source contains estimated water use data for Wyoming by county (or watersheds) for the year 1990 and 1995. For each year, data on surface and groundwater withdrawals and consumptive use is available for the following sectors: public supply, commercial water use, domestic, industrial, mining, livestock, irrigation, power generation (fossil fuels as well as hydroelectric power generation). These data are the most useful for our purpose because of its break-down by county and industry.

- Wyoming Water Plans ( http://waterplan.state.wy.us )

This source contains data by basin. Data are available for water flows and use for different industries. But in almost all cases, there is a single estimate of water use, often a multiple year average, rather than time series information.

The water plans however, are useful because they provide an excellent overview of water uses, interstate compacts as well as current developments in the basin. They also contain projections of various water uses up till 2030.

All basins except Snake/Salt River Basin, Platte River Basin and Wind/Bighorn River Basin have a water plan that is ready and available on the web.

*Economic and demographic data*

- Bureau of Economic Analysis (http://www.bea.doc.gov )

This site contains data on gross state product, wages, and property income, by industry up till 2001. These data are available for each industry (e.g. agriculture, forestry, mining, construction, nondurable goods etc.) The site also contains personal income, per capita personal income and population data on Wyoming up till 2001. Moreover, personal income data broken down by industry and county is also available for the year 2001.

- US Bureau of Census (http://www.census.gov)

This site is very useful because it contains the demographic data for the State for 1990 and 2000. Data are also available for various social (e.g. school enrollment, urban-rural residence, children born per 1000 women etc.), economic (employment by industry, income distribution etc.) and housing characteristics. There are also projections available for the year 2002.

To summarize, we have made excellent progress on locating the data for this project. However, we lack the data for total freshwater availability (i.e., average annual surface runoff and groundwater recharge from endogenous precipitation, including surface inflows from other states). Total water availability is needed to measure relative water demand (i.e. freshwater utilization relative to availability). Currently, the only data on total freshwater availability that are known for Wyoming is from the USGS *Water Resources Data Report* for 2002, which contains information at basin level for a single year.

Most of the modeling effort in FY2003 has focused on developing the basic models relevant to water use and growth in Wyoming. The basic modeling approach for determining how the aggregate rate of water utilization for irrigated farming affects growth in the agricultural sector of the Wyoming economy has been developed (Barbier and Chaudhry 2004). Preliminary work has begun on developing a water of public capital, water use and growth in the municipal and industrial sector (Chaudhry 2004). Future work will focus on applying both of these models to empirical data across Wyoming.

**Student Support:**
Ms Anita Chaudhry is the graduate research assistant employed fulltime on this project, as part of her PhD in Economics studies.

**References:**
Barbier, E.B. 2004. "Water and Economic Growth." *Economic Record* 80: 1-16.

Barbier, E.B. and A. Chaudhry. 2004. "Water and Growth in an Agricultural Economy." Paper to be presented at the Thirteenth Annual Conference of European Association of Environmental and Resource Economists, Budapest University of Economic Sciences and Public Administration, Budapest, 25-28 June 2004.

Chaudhry, A. 2004. "Water, Public Capital and Growth in Municipal and Industries." *Mimeo.* Department of Economics and Finance, University of Wyoming.

Jacobs, James J., and Donald J. Brosz. 2000. "Wyoming's Water Resources." University of Wyoming, Agricultural Experiment Station, August.

Shioji, Etsuro. 2001. "Public Capital and Economic Growth." *Journal of Economic Growth* 6:205-227.